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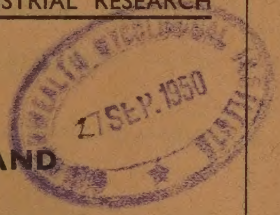

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(AGRICULTURAL RESEARCH SECTION)

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NOTICES

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THE NEW ZEALAND
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CLASSIFICATION OF BARLEY VARIETIES IN NEW ZEALAND

By J. P. MALCOLM, Agronomy Division, Lincoln

(Received for publication 31 January 1949)

Summary

Various morphological characters of barley have been reviewed for use in the classification of varieties grown in New Zealand. Characters most stable under varying environments were utilized for individual variety descriptions and for the arrangement of identification keys.

INTRODUCTION

THE release by plant breeders of numerous agricultural varieties which are closely similar from the taxonomic viewpoint has resulted in difficulty and often confusion in their identification. Varietal performance in barley is commonly measured by physiological characters such as yield, standing ability, disease resistance, and malting quality. However, unless these physiological characters are associated with distinctive morphological characters, absolute identification under diverse environmental conditions is extremely difficult, if not impossible. A further complication arises from the fact that several of the newer agricultural varieties have been derived by mass selection. Individual plants within an agricultural variety may thus show considerable variation.

As long as morphological characters themselves do not have an important effect on the physiological characteristics that determine the value of the variety, they are of minor importance to the plant breeder and of no economic importance to the farmer. However, morphological differences are used by barley specialists in the recognition of agricultural varieties. After acquiring an accurate knowledge of varieties, the presence of 'rogues' or 'off-types' in crops is readily detected. A pure line of grain with high even germination is a necessity for the malting process and also to ensure high yields with even maturity. This last factor is essential for good condition of harvested grain and for the even behaviour of grain on the malting floor.

PREVIOUS CLASSIFICATIONS

The development of systems of barley classification may be traced from 1753 when Linnaeus in his 'Species Plantarum' first delimited species. Linnaeus and his followers utilized spike characters alone for classification.

Field studies were attempted by Kornicke in 1885, but as these were confined to one climatic region and a small range of material, the importance of stability and variability of characters was not apparent.

The study of stability in the field under different environmental conditions was commenced by Harlan (1914, 1918) who realized the need for studying the material in the field and following its development from seeding to maturity under different regional and climatic conditions.

These principles advocated by Harlan, followed by Bell (1937), and later by Aberg and Wiebe (1946) have been followed in this study.

The species classification adopted here to distinguish the small number of agricultural varieties in New Zealand follows that of Kornicke with minor amendments by Beaven (1947).

Hordeum sativum Jess (H. vulgare Kcke.)

Sub-species or Races (Fig. 1)

1. Spike of six rows of spikelets, all fertile.
   A. Wide with short internodes, *H. hexastichum L.*
   B. Narrow, with long internodes, *H. vulgare L. (H. hexastichum Kcke.)*
2. Spike of six rows of spikelets, all fertile—two median rows normal, four lateral rows diminutive and without awns. *H. intermedium Kcke.*
3. Spike with two median rows of spikelets fertile and four lateral rows infertile or staminate.
   A. Wide, with short internodes, *H. zeocriton L.*
   B. Narrow, with long internodes, *H. distichum L.*
4. Spike with two median rows of spikelets fertile and four lateral rows rudimentary and without floral organs. *H. decipiens Steudel.*

METHOD

The classification studies were carried out at Lincoln between 1945 and 1948 with both autumn- and spring-sown material. Confirmatory observations were made by officers of the Department of Agriculture and by the writer throughout the principal barley districts of Marlborough, Canterbury, and Otago.

The varieties at Lincoln were sown at intervals of four inches and two inches and also at normal seeding rate, in rows one foot apart. Detailed notes were recorded in the juvenile stage, shooting period, flowering period, at spike emergence, two weeks after spike emergence, and at binder and header ripe stages. A sample of fifty mature plants was pulled and measurements were recorded in the laboratory. From this sample ten spikes were selected for detailed study.

Varieties described include those grown commercially and those showing promise in trials with possibilities of release. With the exception of Gisborne, all the varieties grown in the Dominion are of overseas origin. The present observations have, therefore, been compared with relevant descriptions in overseas literature. Descriptions of particular varieties and the sources of information include the following:—Gisborne (Archer 1922); Kenia (Anon. 1928); Cape and Pryor (Vears 1935); Chevallier, Plumage Archer, Spratt Archer, and Victory (Bell 1937); Wong (Love and Craig 1943); Pioneer (Bell 1944); Prefect (Anon. 1944); Newal (Aberg and Wiebe 1946); Golden Archer (Beaven 1947).

FIG. 1.—Sub-species of Hordeum sativum, Jess.
Left to right: *H. hexastichum* L.; *H. vulgare* L.; *H. zeocriton* L.; *H. distichum* L.

THE BARLEY PLANT (Fig. 2)

Stem: The cylindrical stem consists of hollow internodes separated by solid nodes at which the leaves arise. The stem and the spike are joined by the collar. Environment and variety determine the length of the stem and the number of stems per plant.

Leaf: (Fig. 3). A single leaf arises at each node and these are borne alternately on either side of the stem. The leaf consists of a sheath, ligule, auricle, and blade. The sheath encloses the stem and is split to the base on the side opposite the blade. In most varieties the sheath is glabrous, but in some it is covered with hairs. The ligule extends upward at the union of the blade and sheath. At its base the blade extends into two claw-shaped auricles which clasp the stem. The uppermost leaf which is called the flagleaf is normally much smaller than the others, and in some varieties is curled or rolled. The blade surface is rough and covered usually with a waxy deposit.

Spike: The spike is made up of flowers attached at nodes of the rachis. The rachis is solid and consists of alternate flattened nodes and internodes. The groups of three spikelets are attached on alternate sides of the rachis, one group above the other. In two-rowed varieties only the central spikelet of each group is fertile and produces a kernel.

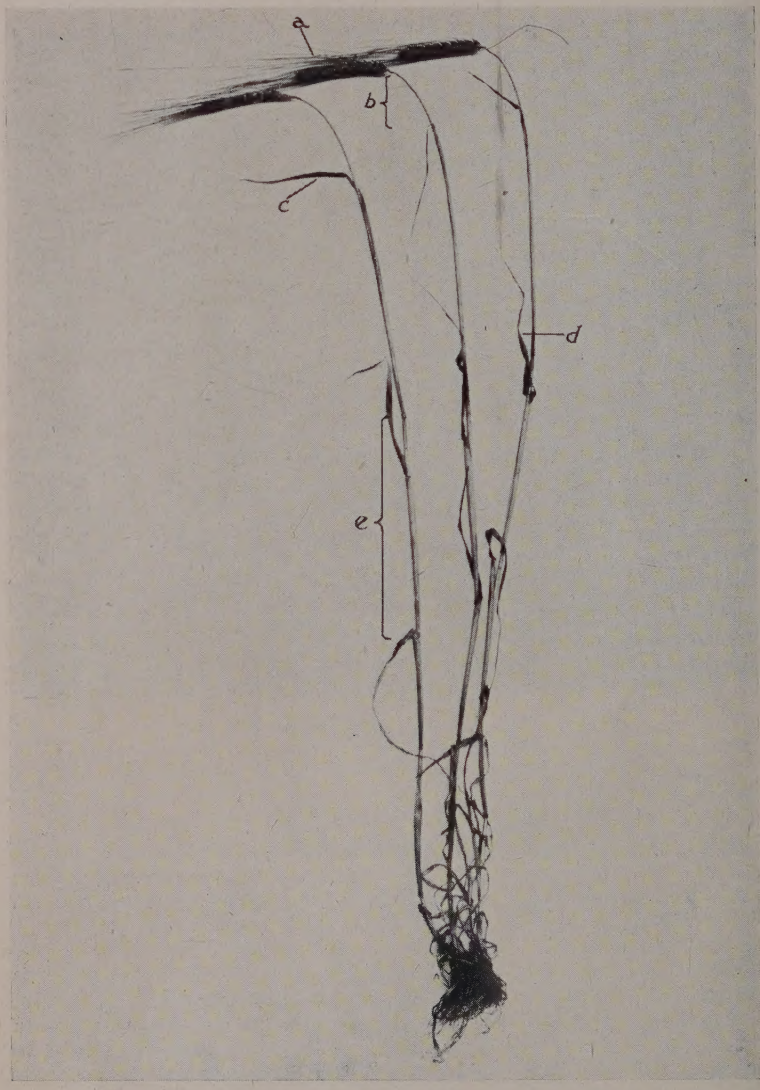

FIG. 2.—Barley plant: (a) Spike; (b) Unsheathed portion of peduncle; (c) Flagleaf; (d) Leaf Blade; (e) Internode.

Spikelet (Fig. 4): A spikelet consists of two glumes and the floret. The two outer glumes are linear, flat, possess small nerves, and terminate in an awn.

Floret (Fig. 5): The floret consists of the lemma, palea, rachilla, and the male and female flower parts. The lemma has five nerves and terminates in a straight awn. The lateral and marginal nerves have, in

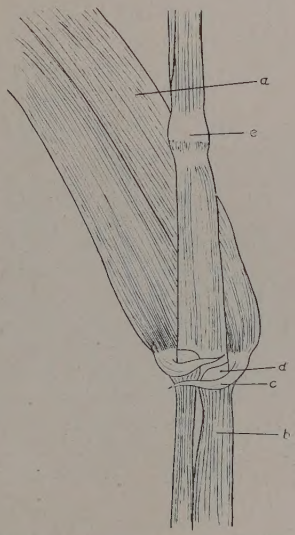

FIG. 3.—Junction of blade and leaf sheath: (a) Blade; (b) Leaf Sheath, (c) Auricle; (d) Ligule; (e) Node. (After Aberg and Wiebe.)

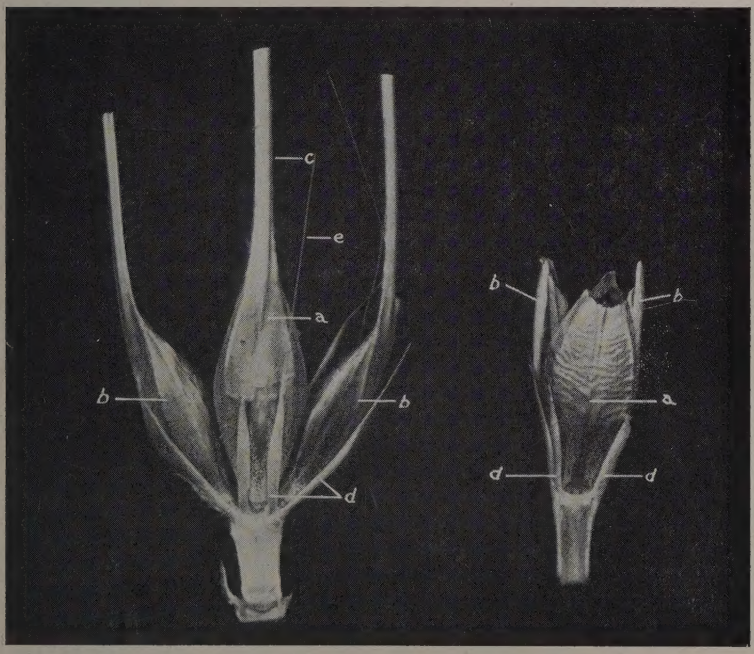

FIG. 4.—Spikelet groups: Left, Six-rowed barley; Right, Two-rowed barley; (a) central kernel; (b) lateral kernels (six-rowed) or sterile lateral florets (two-rowed); (c) awn; (d) outer glumes; (e) glume awns.

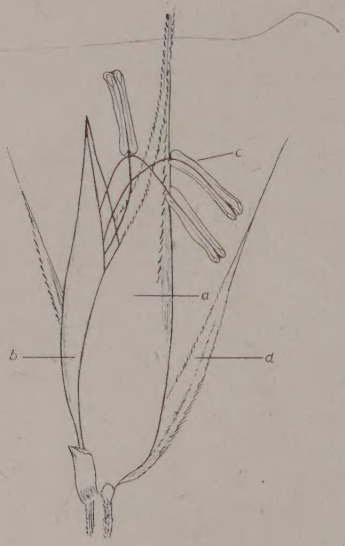

FIG. 5.—Barley floret: (a) lemma; (b) palea; (c) anther; (d) outer glume. (After Aberg and Wiebe.)

some cases, numerous small teeth, but are usually smooth. The lemma may have either a depression or a transverse crease at its base on the dorsal side just above the point of attachment. The awn may be rough or smooth. The palea is curved inwards between its two nerves and is turned inwards at the margins. The rachilla is a continuation of the axis of the spikelet and lies within the crease of the kernel. It is covered with either long or short hairs.

Kernel: The barley kernel consists of the caryopsis and the lemma, palea and rachilla. In most varieties the lemma and palea adhere to the caryopsis, whereas in others they are free and the caryopsis threshes out like wheat.

DESCRIPTIVE CHARACTERS

I. GROWTH CHARACTERS

This section deals with the manner in which the plant grows and its relation to environment and disease.

Spring or Winter Growth Habit: Although it is possible either to autumn- or spring-sow a spring variety and obtain a mature crop, it is found that there is incomplete development of a true winter variety when spring-sown. The only winter varieties in New Zealand are Pioneer and Wong, which are, as yet, not commercially grown. Prefect is described overseas (Anon., 1944) as a winter variety because of a high degree of winter hardiness and its prostrate juvenile habit. However, Prefect completes development and produces a crop when spring-sown. Winter varieties are characterized by a flat, prostrate, juvenile growth habit, while spring varieties tend to be more erect.

Juvenile Habit: In the juvenile leafy stage of growth the barley plant may be 'erect,' 'semi-erect,' or 'prostrate,' depending on the angle of the tillers with the soil (Fig. 6). The density of the strike somewhat modifies the juvenile habit—spaced plants invariably tend to be more prostrate than crowded ones.

Spike Emergence: Emergence is a more accurate index of rate of development than is time of ripening. Three groups are distinguished 'early,' 'midseason,' and 'late,' with a difference in time of emergence of from five to ten days between groups.

Disease Reaction: The question of varietal susceptibility or resistance to disease is of vital economic importance. In New Zealand the most serious diseases have been controlled by various seed treatments. Pickling with fungicides and, latterly, dusting with organic mercurial dusts have effectively controlled covered smut *(Ustilago hordei).* In 1925 hot-water treatment was first used to control loose smut *(Ustilago nuda)* and leaf stripe *(Helminthosporium gramineum);* today it is only on rare occasions that smut can be found in malting barley crops. Rust (*Puccinia* spp.) is prevalent in certain seasons causing shrivelled grain and reduced yield. Powdery mildew *(Erysiphe graminis hordei)* may usually be found in the early part of the season.

Wong is resistant to mildew, as reported by Love and Craig (1943), and Black Skinless shows some degree of resistance. Shands and Arny (1944) report the Newal is moderately resistant to stripe. However, definite reactions cannot be recorded until possible physiologic races of diseases present in the Dominion are determined by artificial innoculations.

FIG. 6.—Juvenile growth habit: Left to right, erect, semi-erect, prostrate.

II. LEAF CHARACTERS

Hairiness of the Leaf Sheath: The lower leaf sheaths of some varieties are covered with hairs which drop off or are broken off as the plant matures. Most varieties in this country are without hairs on the sheath.

Pigmentation of Sheaths and Auricles: The red or purple coloration found in the leaf sheaths at the base of the plant and frequently on the auricles of some varieties is subject to seasonal and environmental fluctuations. The intensity of the colour is more pronounced after periods of prolonged cold weather. As a rule the two-row varieties develop some degree of pigmentation at the base of the culms and often on the auricles, while six-row varieties are always free from pigment.

Colour and Size of Leaves: Length, width, and colour of leaves show considerable variation, but because of difficulty in description and the effect of environment, are used only where differences are outstanding.

Size and Habit of Flagleaf: The size and habit of the flagleaf are observed and recorded at the time of ear emergence. Because of their variability they are included in the variety descriptions as subsidiary descriptive characters.

III. STEM CHARACTERS

Height of Plant: To determine the height of a plant, the distance from the ground to the base of the spike is measured. This character is easily influenced by environment, being useful only when two varieties differ significantly in height under all conditions. The groups used are 'tall,' 'midtall' and 'short.'

Length of Unsheathed Peduncle: The peduncle is that portion of the stem from the last node to the base of the spike. It may be completely sheathed or have a portion unsheathed below the base of the spike. Under adverse growing conditions the peduncle of a variety may be completely sheathed although not normally so. This character offers some assistance in the identification of two-row, lax-eared types.

Strength of Straw: One of the important objectives in barley selection has been the improvement of straw strength. Certain six-row, feed varieties and some of the older two-row varieties in New Zealand are weak in this respect. Straw strength is affected by a number of factors, including diameter and quality of the straw, height of plant, nature of the root system, the stage of plant growth in relation to bad weather, the height and position of the spike and the incidence of stem diseases. Varieties are classed as 'strong,' 'medium strong,' and 'weak.'

IV. SPIKE CHARACTERS

Real differences in spike characters are not shown until at least a fortnight after spike emergence. The most useful spike characters at this and later stages are the number of rows of fertile kernels, the length of awn, the barbing of the awn, the shape, length, and density of the spike, the attitude of the spike, the colour in the awns and glume awns and the deciduousness of the awns.

Fertility: In six-row barleys all three spikelets of the group at a node are fertile, giving six rows of grain around the rachis. In two-row barleys only the centre spikelet of each group of three at a node is fertile, resulting in two rows of grain around the rachis.

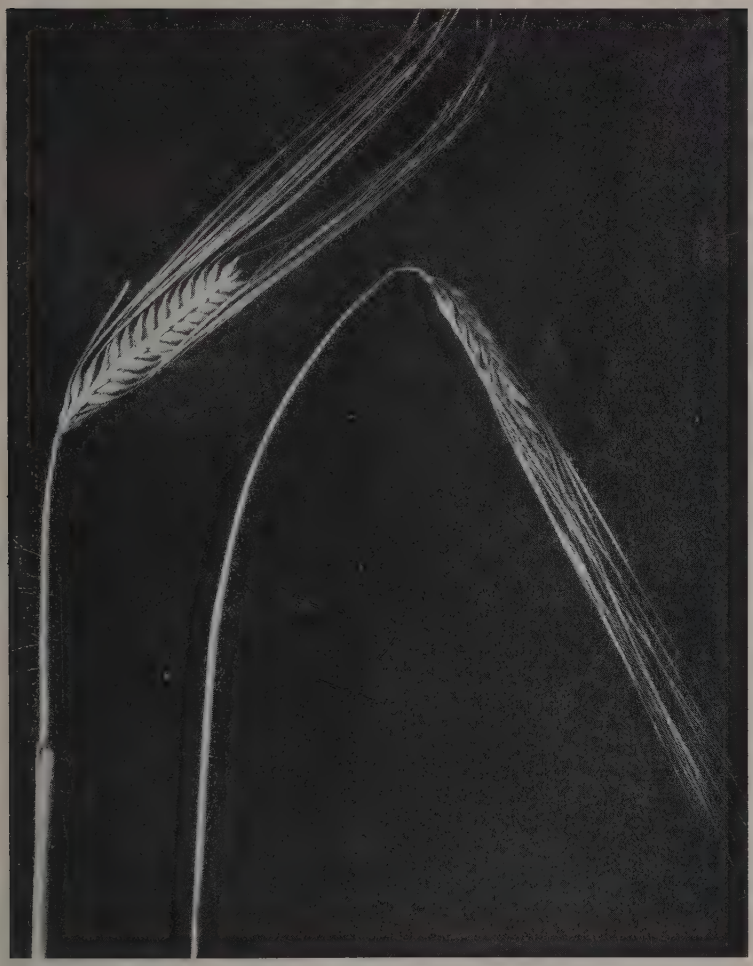

FIG. 7.—Spike shape and attitude: Left, dense and erect; right, lax and drooping.

Length of Awn: All varieties except one in this classification have long awns, about twice the length of the spike. Wong has short awns on the central rows of kernels and very short awns on the lateral rows.

Barbing of the Awn: Most varieties possess awns barbed along the entire length. The one exception in New Zealand is Newal, which has smooth awns.

Deciduousness of the Awns: This is an obvious field character, but is influenced by environment. Varietal differences also exist, and the variation in expression has been stated to be partly due to the ability of the plants to accumulate different quantities of ash in the awns (Pope 1945).

Spike Shape: Two groups of varieties can be distinguished: (1) the parallel type, where the sides are parallel throughout the length of the spike; and (2) the pyramidal type, where the sides converge towards the tip and sometimes towards the base of the spike.

Length of Spike: The existence of large fluctuations limits the use of the character but in some varieties the spikes are very long and in others very short. Three broad groups have been distinguished for descriptions: 'long', 'medium long', and 'short'.

Spike Density: In dense-eared varieties there are more spikelet groups per unit length of rachis than lax-eared varieties. Because of environmental fluctuations, density measurements are not stable within a variety and can therefore be used only where marked differences occur between varieties.

Spike Attitude: Two or three weeks after emergence the spike assumes various attitudes due to the curving of the peduncle or of the rachis at the base of the spike (Fig. 7). Lax-eared varieties assume a nodding habit, but the speed at which this is attained varies. In dense-eared barleys the spike is usually erect, but may finally bend over when the grain is ripe.

Pigmentation of the Spike: Before the grain begins to ripen there is a period when pigment on the lemma awns and glume awns and sometimes the lemma nerves and sterile lateral florets (of two-row varieties) reaches its maximum development. The six-row barleys and the Australian two-row varieties, Pryor and Research, do not develop pigment on

FIG. 8.—Kernel type: Left, covered; Right, naked.

the spikes. Black Skinless is an exception because the lemma and palea become deeply pigmented while the kernel is filling, but the colour fades as the grain ripens, leaving the kernel alone a deep purple colour. The intensity of pigmentation is influenced by weather conditions.

V. GRAIN CHARACTERS

Covered or Skinless Grain: In all varieties in New Zealand, except Black Skinless, the lemma and palea adhere to the caryopsis and are not removed in the threshing process (Fig. 8). Such barleys are termed 'covered' barleys in contrast with 'skinless' barleys.

Shape of Kernels: Samples of six-row barley can be recognized by the uneven size of the individual grains and by the twisted shape of some of the grains. Two-thirds of the grains in the sample will be twisted and somewhat smaller than the remainder. The smaller twisted grains are the lateral grains of the spike. The grain of six-row barleys is usually narrower than that of two-row barleys, which have even-sized symmetrical grains (Fig. 9).

FIG. 9.—Kernel shape: Top row, even-sized symmetrical kernels of two-rowed barley; bottom row, symmetrical central kernel and smaller twisted lateral kernels of six-rowed barley.

FIG. 10.—Base of the Grain: Left, transverse crease; Right, depression.

Length of Kernels: The only useful measurement of kernel size is length, because width and thickness vary too much with environmental conditions. Three groups are used: 'long', 'medium long', and 'short'.

Colour of Caryopsis: The following caryopsis colours are found in local barleys: blue, white, and purple-black. Hector (1936) states that variation in colour is due to the relative distribution of two pigments: a melanin compound which is black, and an anthocynin which is red in acid and blue in alkaline conditions. Harlan (1914) describes the interaction of these pigments as follows: 'White denotes the absence of all pigments; anthocyanin in the aleurone (alkaline) results in blue barley; a skinless barley with blue aleurone and red pericarp (anthocyanin in acid conditions) results in a purple barley.'

Base of the Grain: There may be either a depression or a transverse crease at the base of the lemma on the dorsal side (Fig. 10). The character is often not fully expressed in an individual grain, but it is stable within the group providing suitable grains are selected for examination.

Lemma Teeth: The lemma possesses five nerves, namely, the midnerve, the two lateral nerves next to the midnerve, and and two marginal nerves near the edge of the lemma. The midnerve is always without teeth, but the two lateral nerves may or may not possess teeth near the apex of the lemma (Fig. 11).

Rachilla Hairs: The rachilla may be covered with long straight hairs, or with short downy hairs giving a fuzzy appearance (Fig. 12). No significant differences in the length of the rachilla were found within the range of material tested.

FIG. 11.—Lemma teeth: Left, teeth on lateral nerves; Right, no teeth on lateral nerves.

ORIGIN AND DESCRIPTION OF VARIETIES

The first group contains the two-row barleys arranged in alphabetical order, and the second group the six-row varieties.

TWO-ROW VARIETIES

CHEVALLIER

This very old variety was selected in England in 1820 and repeated selections have been made since then. One selection, Kinver Chevallier, has been the predominant variety for many years in most barley districts of New Zealand, providing good yields of attractive malting grain. Chevallier is now out of cultivation in England because of its long, weak straw. Lodging is frequent on heavy land in this country.

Description: Two-rowed spring barley; *Hordeum distichum* L.; juvenile growth habit semi-erect; plant late, tall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, medium wide, rolled, twisted; top of peduncle mostly unsheathed; spike lax, long, parallel, nodding; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla short haired; kernels white, long, uniform shape and size (Fig. 13).

FIG. 12.—Rachilla hairs: Left, short hairs; right, long hairs.

GISBORNE

Gisborne was at one time popular in certain districts with the synonym of 'Wind-resistant', but did not prove superior to other varieties in this respect. Its origin is uncertain, but it is probably a New Zealand selection of Spratt. There is considerable variation in many characters within the line. The straw is moderately strong, and frequently the very dense spike assumes a twisted shape.

Description: Two-rowed spring barley, *Hordeum zeocriton* L., juvenile growth habit semi-erect; plant late, midtall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, medium wide, not rolled, twisted; top of peduncle mostly unsheathed; spike dense, short, tapering, erect; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla short haired; kernels white, short, uniform shape and size (Fig. 14).

GOLDEN ARCHER

This is a mass selection from a cross between Plumage Archer and Spratt Archer made in England. In appearance it is very similar to Spratt Archer. In extensive field trials since being introduced in 1937, it has shown distinct promise as a high yielding, good quality barley with the ability to stand well until ready for harvesting. On the heaviest land Golden Archer has lodged to a slight extent. A substantial area of the variety was sown in Canterbury during the 1947-48 season.

Description: Two-rowed spring barley; *H. distichum* L.; juvenile growth habit semi-erect; plant late, short; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf short, narrow, rolled, twisted; top of peduncle mostly sheathed; spike lax, long, parallel, nodding; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla long haired; kernels white, medium long, uniform shape and size (Similar to Fig. 19).

GOLDTHORPE SPRATT

This variety was first grown in New Zealand in 1924, but has never been grown on an extensive scale. It has been popular on the lighter soils of Central Otago and Marlborough where it yields well. It is recognized as the best variety for malting, but is subject to lodging and shaking.

Description: Two-rowed spring barley; *H. zeocriton* L.; juvenile growth habit semi-erect; plant late, tall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, narrow, rolled, twisted; top of peduncle mostly unsheathed; spike dense, medium long, parallel, erect to inclined; awn long, barbed, pigmented, deciduous; lemma with transverse crease at base, no teeth on lateral nerves; rachilla long haired; kernels white, long, uniform shape and size (Fig. 15).

H.H. 12 CULTURE 9

Received in 1945 from the Plant Breeding Institute, Cambridge University, Culture 9 is a promising new unnamed selection from a cross between Maja and Spratt. It has a short, stiff straw, is early, gives a very good yield, but is only of average malting quality. Its best feature is its ability to stand until header-ripe without shaking or neck-break.

Description: Two-rowed spring barley; *H. distichum* L.; juvenile growth habit semi-erect; plant midseason, short; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, narrow, rolled, twisted; top of peduncle invariably sheathed; spike lax; medium long, parallel, nodding; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla long haired; kernels white, long, uniform shape and size (similar to Fig. 16).

KENIA

Kenia is a Danish barley derived from the cross between Binder and Gold. In most respects it is similar to Culture 9.

Description: Two-rowed spring barley; *H. distichum* L.; juvenile growth habit semi-erect; plant midseason, short; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf short, narrow, rolled, twisted; top of peduncle nearly always sheathed; spike lix; short, parallel, nodding; awn long, barbed, pigmented; lemma with depression at base, teeth on lateral nerves; rachilla long haired; kernels white, medium long, uniform shape and size (Fig. 16).

PIONEER

This is a recently developed winter malting barley from the Plant Breeding Institute, Cambridge University. It is a hybrid from a cross between Spratt Archer and Tschermak's two-row winter barley. Because of its winter hardiness, high yield, and good malting quality the variety may suit certain districts of New Zealand where autumn sowing is practised. Pioneer is definitely unsuitable for spring sowing.

Description: Two-rowed winter barley; *H. distichum* L.; juvenile growth habit prostrate; plant late, midtall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, medium wide, rolled, not twisted; top of peduncle usually unsheathed; spike lax, long, parallel, nodding; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla long haired; kernels white, medium long, uniform shape and size (similar to Fig. 19).

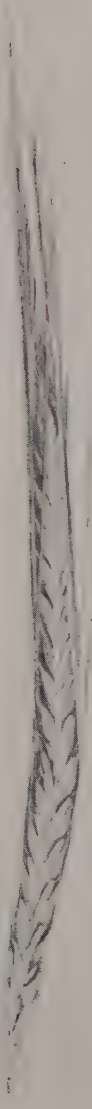

FIG. 13.—Chevallier.

FIG. 14.—Gisborne.

FIG. 15.—Goldthorpe Spratt.

FIG. 16.—Kenia.

PLUMAGE ARCHER

The variety originated from a cross between Plumage and Archer made by Dr. Beaven in 1905. It was introduced to New Zealand in 1924 and became popular because of its strong straw and standing ability on heavy land where where it gives good yields of relatively good quality grain. Neck-break reduces yield considerably in some cases.

Description: Two-rowed spring barley; *H. zeocriton* L.; juvenile growth habit semi-erect; plant late, tall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, medium wide, rolled, twisted; top of peduncle mostly unsheathed; spike dense, short, tapering, erect; awn long, barbed, pigmented; lemma with transverse crease at base, no teeth on lateral nerves; rachilla long haired; kernels white, long, uniform shape and size (Fig. 17).

PRYOR

Pryor is an early maturing Australian variety introduced into Nelson and Blenheim in 1937 and is now the predominant variety under the name of "Marlborough Chevallier". It is frequently confused with Kinver Chevallier, but is quite distinct in appearance and performance. Its early maturity suits the practice of late sowing, and also short, dry growing seasons. The straw is weak and the malting quality definitely poor.

Description: Two-rowed spring barley; *H. distichum* L.; juvenile growth habit erect; plant early, short; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, narrow, not rolled, twisted; top of peduncle mostly unsheathed; spike lax, medium long, slight taper, nodding; awn long, barbed, not pigmented; lemma with depression at base, teeth on lateral nerves; rachilla short haired; kernels white, short, uniform shape and size (Fig. 18).

RESEARCH

Research was derived from a cross between Plumage Archer and Pryor made in Australia. It has rapidly become popular in the Ellesmere Springs district and the substantial areas grown since the 1945-46 season have provided good yields of less than average quality grain. It matures about 10 days earlier than Plumage Archer and stands well for direct heading. The straw is moderately strong.

Description: Two-rowed spring barley; *H. zeocriton* L.; juvenile growth habit semi-erect; plant early, midtall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide, flagleaf medium long, narrow, not rolled, twisted; top of peduncle mostly unsheathed; spike dense, short, slight taper erect; awn long, barbed, not pigmented; lemma with transverse crease at base, no teeth on lateral nerves; rachilla long haired; kernels white, long, uniform shape and size (similar to Fig. 17).

SPRATT ARCHER

Spratt Archer originated from a cross between Irish Archer and Spratt made by Dr. Hunter in Ireland in 1908. It was introduced into New Zealand just before 1924, and is now one of the most important varieties in New Zealand. With short, strong straw, Spratt Archer produces good yields of excellent quality grain under most conditions.

Description: Two-rowed spring barley; *H. distichum* L.; juvenile growth habit semi-erect; plant late, short; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, narrow; flagleaf short, narrow, rolled, not twisted; top of peduncle sheathed; spike lax, long, paralled, nodding; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla long haired; kernels white, medium long, uniform shape and size (Fig. 19).

FIG. 17.—Plumage Archer. FIG. 18.—Pryor. FIG. 19.—Spratt Archer.

VICTORY

This variety was introduced from England in 1937, but differs from the European description in having a short-haired rachilla. Overseas reports also mention its good standing ability which is not evident in crops grown here. A few hundred acres have been grown in Canterbury.

Description: Two-rowed spring barley; *H. distichum* L.; juvenile growth habit semi-erect; plant midseason, midtall; basal leaf sheaths non-hairy; base of culms pigmented; leaves medium long, medium wide; flagleaf medium long, wide, not rolled, not twisted; top of peduncle mostly unsheathed; spike lax, long, parallel, nodding; awn long, barbed, pigmented; lemma with depression at base, no teeth on lateral nerves; rachilla short haired; kernels white, medium long, uniform shape and size (similar to Fig. 16).

SIX-ROW VARIETIES

CAPE

This is the most popular feed variety grown, occupying about 10 per cent of the total barley area. It has been grown in New Zealand for many years and originated in the Cape of Good Hope district in South Africa. The straw is weak and neck-break is common.

Description: Six-rowed spring barley; *H. vulgare* L.; juvenile growth habit semi-erect; plant early midtall; basal leaf sheaths with a few hairs; base of culms not pigmented; leaves medium long, wide, flagleaf medium long, wide, rolled, twisted; top of peduncle usually unsheathed; spike lax, short, parallel, erect; awn long, barbed, not pigmented; lemma with transverse crease at base, teeth on lateral nerves; rachilla short haired; kernel blue, long, varying shape and size (Fig. 20).

BLACK SKINLESS

Black Skinless is grown mainly to provide grazing in the autumn and winter. It has weak straw and is subject to neck-break. About 6 per cent of the barley area is stated to be in this variety. Its origin was probably in the northern region of India.

Description: Six-rowed spring barley; *H. vulgare* L.; juvenile growth habit erect; plant early, midtall; basal leaf sheaths non-hairy; base of culms not pigmented; leaves medium long, wide; flagleaf medium long, wide, rolled, not twisted; top of peduncle usually unsheathed; spike lax, short, tapering, nodding; awn long, barbed, pigmented; lemma with depression at base, teeth on lateral nerves; rachilla long haired; kernel purple-black, short, varying shape and size.

NEWAL

This variety was introduced into New Zealand in 1937 from the University of Alberta, Canada. A few crops have been grown in recent seasons in Canterbury. The straw is medium strong but severe shaking occurs even before the grain is ripe. Newal produces a very fast, bulky greenfeed crop which will not, however, stand up to repeated grazing.

Description: Six-rowed spring barley; *H. vulgare* L.; juvenile growth habit erect; plant early, midtall; basal leaf sheaths non-hairy; base of culms not pigmented; leaves medium, long, wide; flagleaf medium long, wide, rolled, not twisted; top of peduncle usually unsheathed; spike lax, medium long, parallel, nodding; awn long, smooth, not pigmented; lemma with transverse crease at base, no teeth on lateral nerves; rachilla long haired; kernel white, long, varying shape and size (Fig. 21).

WONG

Wong is a hybrid barley produced in China, and now grown as a winter barley in the north-eastern states of America. It shows promise of being useful for winter grazing. The straw is strong and erect.

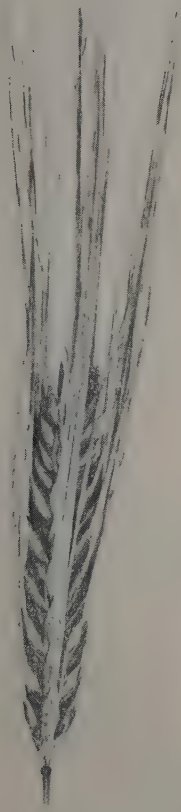

FIG. 20.—Cape.

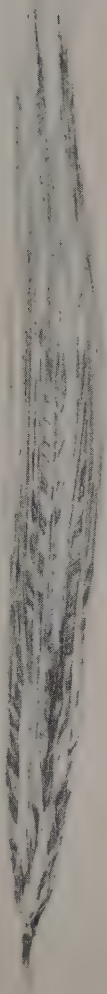

FIG. 21.—Newal.

FIG. 22.—Wong.

Description: Six-rowed winter barley; *H. hexastichum* L.; juvenile growth habit prostrate; plant late, midtall; basal leaf sheaths hairy; base of culms not pigmented; leaves medium long, medium wide; flagleaf medium long, medium wide, rolled, not twisted; top of peduncle usually unsheathed; spike dense, short, parallel, erect; awn very short, barbed, not pigmented; lemma with depression at base; teeth on lateral nerves; rachilla long haired; kernels pale blue, medium long, varying shape and size (Fig. 22).

PREFECT

Prefect was obtained from the Plant Breeding Institute, Cambridge, England, in 1945. It is a recently selected hybrid barley from a cross between Praecox (a European six-row winter barley) and Spratt Archer. The straw is very long but is moderately strong and stands well. Prefect is a winter hardy grazing barley that produces a good plump feed grain.

Description: Six-rowed spring barley; *H. vulgare* L.; juvenile growth habit prostrate; plant late, tall; basal leaf sheaths non-hairy; base of culms not pigmented; leaves medium long, medium wide; flagleaf medium long, medium wide, rolled, twisted; top of peduncle usually unsheathed; spike lax, medium long, parallel, nodding; awn long, barbed, not pigmented; lemma with depression at base, teeth on lateral nerves; rachilla short haired; kernels white, long, varying shape and size.

IDENTIFICATION KEYS

JUVENILE STAGE

A. Erect habit.
- I. Leaf sheath non-hairy.
  - (a) Very wide leaves.
    - (i) No pigment on culms — **Newal**
  - (b) Medium wide leaves.
    - (ii) Pigment on culms. — **Pryor**

B. Semi-erect habit.
- I. Leaf sheath non-hairy.
  - (a) Very wide leaves.
    - (i) No pigment on culms. — **Black Skinless**
  - (b) Medium wide leaves.
    - (ii) Pigment on culms. — **Chevallier**, **Culture 9**, **Gisborne**, **Golden Archer**, **Goldthorpe Spratt**, **Kenia**, **Plumage Archer**, **Research**, **Victory**
  - (c) Narrow leaves.
    - (ii) Pigment on culms. — **Spratt Archer**
- II. Leaf sheath hairy.
  - (a) Very wide leaves.
    - (i) No pigment on culms. — **Cape**

C. Prostrate habit.
- I. Leaf sheath non-hairy.
  - (b) Medium wide leaves.
    - (i) No pigment on culms. — **Prefect**
    - (ii) Pigment on culms. — **Pioneer**
- II. Leaf sheath hairy.
  - (b) Medium wide leaves.
    - (i) No pigment on culms. — **Wong**

POST EMERGENCE PERIOD

A. Six-rowed.
  I. No pigment on spike.
    (a) Long haired rachilla.
      (i) Dense eared.
        Spike erect. — **Wong**
      (ii) Lax eared.
        Spike nodding. — **Newal**
    (b) Short haired rachilla.
      (ii) Lax eared.
        Spike erect. — **Cape**
        Spike nodding. — **Prefect**
  II. Pigment on lemma.
    (a) Long haired rachilla.
      (ii) Lax eared.
        Spike nodding. — **Black Skinless**

B. Two-rowed.
  I. No pigment on spike.
    (a) Long haired rachilla.
      (i) Dense eared.
        Spike erect. — **Research**
    (b) Short haired rachilla.
      (ii) Lax eared.
        Spike nodding. — **Pryor**
  II. Pigment on sterile lateral spikelets and awn tips
    (a) Long haired rachilla.
      (i) Dense eared.
        Spike erect. — **Goldthorpe Spratt**, **Plumage Archer**
      (ii) Lax eared.
        Spike nodding.
          Peduncle invariably sheathed. — **Culture 9**, **Spratt Archer**
          Peduncle occasionally sheathed. — **Golden Archer**
          Peduncle usually unsheathed. — **Kenia**, **Pioneer**
    (b) Short haired rachilla.
      (i) Dense eared.
        Spike erect. — **Gisborne**
      (ii) Lax eared.
        Spike nodding. — **Chevallier**, **Victory**

GRAIN CHARACTERS

A. Covered grain.
  I. Short haired rachilla.
    (a) Depression at grain base.
      (i) Even shape and size.
        No teeth on lateral lemma nerves. — **Chevallier**, **Gisborne**, **Victory**
        Teeth on lateral lemma nerves. — **Pryor**
      (ii) Uneven shape and size.
        Teeth on lateral lemma nerves. — **Prefect**
    (b) Transverse crease at grain base.
      (ii) Uneven shape and size.
        Teeth on lateral lemma nerves.
          Blue colour. — **Cape**
  II. Long haired rachilla.
    (a) Depression at grain base.
      (i) Even shape and size.
        No teeth on lateral lemma nerves. — **Culture 9**, **Golden Archer**, **Pioneer**, **Spratt Archer**
        Teeth on lateral lemma nerves. — **Kenia**
      (ii) Uneven shape and size.

Teeth on lateral lemma nerves.	
Pale blue colour.	**Wong**
(b) Transverse crease at grain base.	
(i) Even shape and size.	
No teeth on lateral lemma nerves.	**Goldthorpe Spratt Plumage Archer Research**
(ii) Uneven shape and size.	
No teeth on lateral lemma nerves.	**Newal**
B. Skinless grain.	
Purple black colour.	**Black Skinless**

One realizes that in work of this kind it is difficult to avoid errors and any modification or correction would be welcomed by the writer.

ACKNOWLEDGMENTS

Acknowledgment is made to Mr R. C. Blackmore, Visual Aids Officer, Canterbury Agricultural College, for preparation of the photographs, and also to Miss M. E. Fairmaid, Agronomy Division, for the preparation of Figs. 3 and 5.

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A NOTE ON MORTALITY AND FERTILITY IN A NEW ZEALAND ROMNEY MARSH STUD-FLOCK IN 1938—THE SEASON OF THE FACIAL ECZEMA OUTBREAK

By H. Goot, Massey Agricultural College, Palmerston North.

(Received for publication, 1st June, 1949)

Summary

The most severe outbreak of facial eczema in sheep in New Zealand occurred in the autumn of 1938 (Cooper and Walker 1940, Cunningham *et al.* 1942, and Levy 1942). As there is little, if any, factual information on losses incurred in facial eczema epidemics, a short table is presented pertaining to a stud flock which was affected by the 1938 outbreak. The stud concerned, called Stud B, has been described before (Goot 1946).

Table I shows the percentage: (i) of ewes which died or were missing *between mating and docking* (ewes which died at parturition without giving birth to a lamb are also included in this column); (ii) of dry and aborting ewes (some ewes whose lambs were stillborn or died soon after birth are probably included in this column); (iii) of multiple births; and (iv) of lambs docked.

Even allowing for a considerable margin of error in these data, there is little doubt that the stud flock was severely affected in the 1938 season. The average mortality and percentage of dry ewes increased between three and four times. On the other hand, the incidence of multiple births and the percentage of lambs docked decreased by one-half. It is of interest to note that the relative decrease in percentage of lambs docked is remark-

Table I.

Age-group.	No. of Ewes Put to Ram.	Ewes Dead or Missing.[1] Per cent.	Ewes Dry or Aborting. Per cent.	Multiple Births. Per cent.	Lambs Docked. Per cent.
1938 Facial Eczema Year.					
2-tooth	67	19.4	41.8	9.0	41.8
4-tooth	66	10.6	45.5	16.7	54.5
6-tooth	54	16.7	33.3	24.1	63.0
F.M. and over	105	24.8	31.4	27.6	62.9
Total	292	18.8	37.3	20.2	56.2
1941-45 Seasons.					
2-tooth	617	2.1	17.8	20.6	84.3
4-tooth	431	3.5	10.2	33.9	109.7
6-tooth	353	6.5	4.8	45.6	123.5
F.M. and over	492	7.9	6.7	50.0	119.9
Total	1,893[2]	4.8	10.4	35.9	106.7

[1] Between mating and docking.

[2] Total number of ewes in 5 year period.

All percentages based on number of ewes put to the ram.

ably even in all age-groups, although the factors responsible varied considerably in the different age-groups. In the 2-tooths, for example, the mortality was over nine times heavier than in seasons free of facial eczema, but figures for dry and aborting ewes were only about twice as high; almost the reverse situation obtains in 6-tooths.

It is emphasized that this note is based on one flock, and it may or may not be typical of the situation obtaining generally.

Thanks are due to Mr E. A. Clarke for reading critically the manuscript and for helpful suggestions.

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STUDIES ON SOME NEW ZEALAND ROMNEY MARSH STUD-FLOCKS:

PART III. TUPPING SEASON

By H. GOOT, Massey Agricultural College, University of New Zealand, Palmerston North, New Zealand.

(*Received for publication, 6 February 1949.*)

Summary

(1) The following aspects of the tupping season have been examined: Distribution of the occurrence of first and last oestrus periods within the tupping season; duration of oestrus period and dioestrus cycle; repeatability of the occurrence of the first oestrus in successive tupping seasons; mating of rams by hand service.

(2) The investigation indicated that: (a) the first oestrus within the tupping season occurred from the second week in March to the second week in May; (b) the last oestrus in the tupping season depended mainly on the average number of tuppings per ewe; (c) the duration of oestrus ranged from one to four days; (d) the length of the dioestrus cycle ranged from 4 to 55 days with a mean of 17.2 days, and in 93 per cent. of cases the range was between 14 and 19 days; (e) no statistically significant differences in the length of the dioestrus cycles could be attributed to either age or season; (f) in the case of the rams during the tupping season, from a half to three-quarters of the days were spent either idly or with one, two, or three matings daily; (g) the average number of tuppings per ewe was 1.3.

INTRODUCTION

IN a previous paper the author (Goot, 1946b) dealt with the age composition of a stud flock prior to the tupping season. In this paper, certain data relating to the tupping season, which is herein defined as that part of the sexual season during which the rams are run with the ewes, are presented and analysed. The scope of the investigation was necessarily conditioned by the fact that most of the data on which the paper is based was recorded by a stud-master for his own use and not expressly for the purpose of making this study possible.

As breeders have found that stud ewes in the Manawatu district seldom come on heat during the first week of March (Buchanan 1945), the rams or the 'teasers' are not turned out until between the 6th and 10th of March. As none of the 1,418 ewes, in all the seven years under review, was recorded as having been tupped before 11 March, this date was chosen for all the years and age-groups as the first day of the tupping season.

OCCURRENCE OF THE FIRST OESTRUS

The percentages of ewes exhibiting within a week, their first heat in the tupping season were tabulated separately for each age-group and year in Tables I and II. Data for the years 1943 and 1944 were not available because hand-service was not carried out in these seasons. The average proportion of ewes exhibiting the first oestrus in the tupping season was three per cent in the first week, rising rapidly to 16 per cent in the second, 30 per cent in the third and 31 per cent in the fourth; thereafter it fell abruptly to less than 10 per cent in each of the subsequent two weeks and less than two per cent in each of the last two to three weeks. The time interval elapsing between the first and last ewe coming on heat might appear to be rather great, but reference to work of similar nature, although based mostly on the sexual season, e.g., McKenzie and Terrill (1937), Schott *et al.* (1939), Walker (1943), and Hammond (1944) shows that it is not atypical. It should be stressed, however, that nearly 60 per cent of ewes, on the average, come on heat during the third and fourth weeks of the tupping season, i.e., the last week of March and the first week of April. In this respect the differences between the age-groups (Table I) ranged from 52 per cent for 2-tooth to 67 per cent for 6-tooth, and between the years (Table II) from 47 per cent in 1939 season to 82 per cent in 1942 season.

The percentage of ewes which came on heat up to the end of the fifth week of the tupping season is also important, as it marks the approximate completion of the second 'colour' round of the sires.*

It will be seen that nearly 89 per cent of all ewes, on the average, came on heat within the first five weeks of the tupping season. The differences between age-groups ranged from 82 per cent for 2-tooth to 94 per cent for full-mouth and 5½-year-old ewes, and between the years, from 69 per cent in the 1939 season to 99 per cent in the 1942 season.

Although the differences between seasons were more pronounced than between the age-groups, yet in the latter a distinct trend could be discerned. The 2-tooth and 6½-year-old and older ewes were slower in coming on the first heat during the tupping season than the remaining age-groups. As to seasonal differences it will be noted in Table II that the onset of the tupping season in 1937 and 1938 was retarded and the season started, rather atypically, at a very high level, in the second week. In all the other years, however, the first ewe was tupped between the 11th and 17th March, usually nearer the latter date. The effect of seasonal conditions, however, is most pronounced during the first five weeks of the tupping season, and especially during the peak period, viz., last week of March and first week of April. Season influenced but little the time interval between the first ewe and the last coming on heat for the first time in the tupping season, the difference being only one week. Thus it seems that whether a season is, what a breeder calls, a good or a bad one depends, apart from the fertility of rams, on the way the ewes come on heat during those five weeks and particularly on the peak period of the tupping season.

The distribution of the occurrence of the first oestrus within the tupping season can also be classified in 17-day intervals corresponding to the mean

* The brisket of sires are raddled to mark the ewes which are tupped, the colour of the raddle being usually changed on every 17th or 18th day, and thus each 'colour' round approximates the average length of the oestrus cycle. (See also Goot 1946a.)

TABLE I. DISTRIBUTION OF THE OCCURRENCE OF THE FIRST OESTRUS WITHIN THE TUPPING SEASON, IN EWES OF DIFFERENT AGES

Percentages based on total tuppings in 7 seasons.

No. of ewes. Age.		392 2-tooth	307 4-tooth	258 6-tooth	283 Full-mouth and 5½ years.	178 6½ years and over.	Grand Total.	
Weeks.		%	%	%	%	%	No.	%
No.	Date.							
1.	11.3 - 17.3	3.6	2.3	1.6	4.2	2.8	42	3.0
2.	18.3 - 24.3	13.0	12.7	16.3	17.7	24.2	225	15.9
3.	25.3 - 31.3	30.6	30.3	25.2	32.9	28.7	422	29.8
4.	1.4 - 7.4	22.2	32.3	41.8	32.2	29.2	437	30.8
5.	8.4 - 14.4	13.0	6.8	8.9	7.4	6.7	128	9.0
6.	15.4 - 21.4	10.2	11.4	4.6	4.2	7.3	112	7.9
7.	22.4 - 28.4	2.8	2.6	1.6	—	1.1	25	1.7
8.	29.4 - 5.5	4.3	1.6	—	1.4	—	26	1.8
9.	6.5 - 12.5	0.3	—	—	—	—	1	0.1
	Total	100.0	100.0	100.0	100.0	100.0	1,418	100.0

Table II. Distribution of the Occurrence of the First Oestrus within the Tupping Season in Ewes in Different Years

No. of ewes / Year.		155 1937	227 1938	231 1939	306 1940	207 1941	136 1942	156 1945	Grand Total.	
Weeks.		%	%	%	%	%	%	%	No.	%
No.	Date.									
1.	11.3 - 17.3	—		1.3	3.6	6.8	1.5	7.7	42	3.0
2.	18.3 - 24.3	31.6	23.8	7.4	12.1	12.0	11.0	18.0	225	15.9
3.	25.3 - 31.3	32.3	23.8	20.8	39.5	17.4	45.6	32.7	422	29.8
4.	1.4 - 7.4	25.2	28.6	26.0	23.9	47.3	36.8	33.3	437	30.8
5.	8.4 - 14.4	6.5	10.6	13.0	8.8	11.6	3.7	5.1	128	9.0
6.	15.4 - 21.4	2.6	7.9	19.0	11.1	3.9	0.7	1.9	112	7.9
7.	22.4 - 28.4	0.6	4.0	5.1	0.3	0.5	0.7	—	25	1.7
8.	29.4 - 5.5	0.6	1.3	7.4	0.7	0.5	—	1.3	26	1.8
9.	6.5 - 12.5	0.6	—	—	—	—	—	—	1	0.1
	Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	1,418	100.0

length of the oestrus cycle. The following are the percentages thus computed: 11 to 27 March, 30.7; 2 March to 13 April, 56.3; 14 to 30 April, 11.7; and 1 to 17 May, 1.3.

OCCURRENCE OF THE LAST OESTRUS

Those ewes which do not conceive at the first heat period in the tupping season come on heat again until they are either in-lamb or the rams are withdrawn. Therefore, the shape of the curve of the last tupping depends on the fertility of both sexes and its variations throughout the season, on the duration of the tupping season and on the distribution of the time of occurrence of the first oestrus within the tupping season.

In Fig. 1 the distributions of the first and last oestrus periods in the tupping season are compared. These curves are based on the records of rams whose average number of tuppings per ewe varied from 1.1 to 1.8. Generally it may be said that the similarity of these two curves decreases with the increases in the average number of tuppings per ewe. However, it should be stressed that Fig. 1 must not be regarded as showing the only possible relationship between these curves, because the average number of tuppings per ewe does not give any direct indication of the variations in fertility throughout the tupping season.

The curve of last oestrus indicates approximately the distribution of lambing. This will be discussed in some detail in a later paper.

OESTRUS PERIOD

Oestrus was indicated by the ewe standing for the teaser, but its duration could be ascertained for the 1945 season only, as in this year every endeavour was made to allow the ewe to be served in the morning and evening of each day as long as she would accept the ram (Goot 1946a).

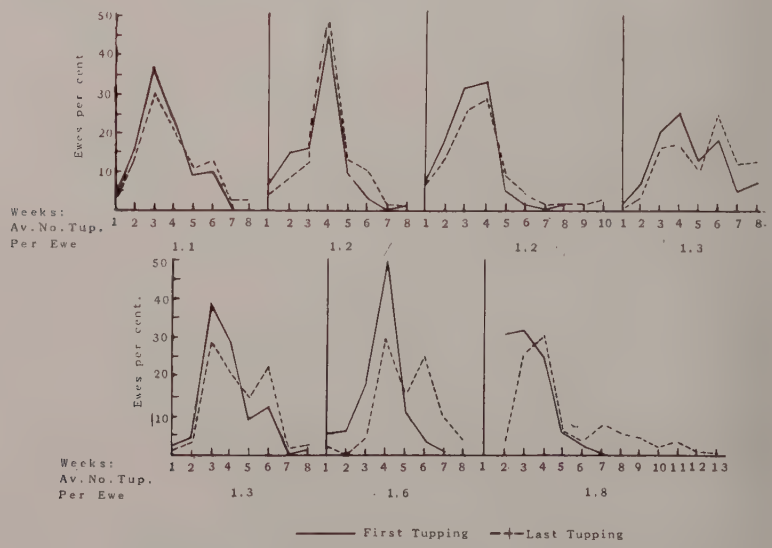


FIG. 1.—Distribution of the first and last oestrus periods (or first and last tuppings) in the tupping season in ewes put to rams whose average number of tuppings per ewe ranged from 1.1 to 1.8. With ewes which have not 'returned' first tupping = last tupping.

Table III. Length of Oestrus Period in Ewes in 1945 Season

Age-Group.	Length of Oestrus Period.					Total.
	Less than 1 day.	1 day.	2 days.	3 days.	4 days.	
	%	%	%	%	%	No.
2-tooth	1.1	69.0	24.1	4.6	1.1	87
4-tooth	6.5	77.4	12.9	3.2	—	31
6-tooth	—	57.7	38.4	3.8	—	26
Full-Mouth to 5½ years	—	51.4	45.7	2.9	—	35
6½ years and over	—	100.0	—	—	—	8
Total No.	3	125	51	7	1	187
%	1.6	66.9	27.3	3.7	0.5	100.0

Table III gives the duration of 187 oestrus periods for 156 ewes of different ages. The individual periods were classified for length as follows: (1) less than one day—ewes tupped by the teaser but refusing to stand for the ram when brought in; (2) one day—ewes served on one day and refusing service on the next morning; (3) two days—ewes served on two consecutive days and refusing service on the third morning, and so on. Obviously, measuring the length of oestrus in days cannot be very precise, and therefore a considerable margin of error must be allowed for (McKenzie and Terrill 1937, Kelley 1937, and others).

The duration of oestrus ranged from less than one day to four days. There were less than two per cent of periods shorter than one day, 67 and 27 per cent lasting respectively one and two days, and four per cent lasting more than two days.

The results obtained by other workers (Roux 1936, McKenzie and Terrill 1937, Kelley 1937, Kirillov 1938, and many others) show considerable variations in the length of oestrus period in different breeds, individuals, ages, seasons, and localities. The only previous observation on Romneys in this country indicated an oestrus period of 1.47 ± 0.7 days (Walker 1943).

Dioestrus Cycle

The periodicity of oestrus, or the length of dioestrus cycle was calculated from the date of the first hand service within an oestrus period, to the date of the first hand service within the next oestrus period. In this way 575 dioestrus cycles were ascertained and the relevant data are set out in Table IV. These figures are similar to those published by other workers (Milowanow 1932, Roux 1936, McKenzie and Terrill 1937, and many others), and for Romneys in this country by Gill (1933), Dry (1933), Webster (1937) and Walker (1943).

Differences in the length of dioestrus cycles due to age of ewes were found to be statistically not significant, a conclusion reached previously by McKenzie and Phillips (1931) and McKenzie and Terrill (1937). Similarly, the differences between the means of the years were found to

TABLE IV. DURATION OF DIOESTRUS CYCLE IN EWES IN DIFFERENT YEARS

Year.	No. of cycles.	Mean ± S.E.	Restricted Mean.*	Mode.	Range.	Per cent within 15-18 days.	Per cent. within 14-19 days.
		Days.	Days.	Days.	Days.		
1937	148	17.86 ± 0.39	16.98	17	9 - 55	85.7	89.7
1938	188	16.88 ± 0.25	16.76	17	4 - 48	87.8	94.2
1939	52	16.81 ± 0.49	16.48	16	6 - 34	92.4	92.4
1940	53	17.42 ± 0.63	16.36	17	14 - 39	79.2	94.4
1941	71	16.63 ± 0.19	16.74	17	10 - 22	87.3	95.7
1942	36	16.58 ± 0.24	16.59	16	12 - 21	88.9	94.4
1945	27	17.70 ± 1.51	15.06	15	13 - 53	77.8	85.2
Total	575	17.17 ± 0.17	16.68	15 - 17	4 - 55	86.4	92.7

* Based on cycles within 14 to 19 days.

be statistically not significant, but further investigations of this aspect would seem desirable in view of the conflicting results obtained by other workers (Grant 1934, Elpatjevskii 1934, McKenzie and Terrill 1937, and Briggs *et al.* 1942).

As shown in Table IV, 92.7 per cent of dioestrus cycles fall within 14 to 19 days, but this varies in different seasons. Webster (1937) found amongst ewes from New Zealand Romney flocks that 95 per cent of cycles fell within this range. Assuming, after McKenzie and Terrill (1937), that this restricted range can be regarded as 'normal,' 7.3 per cent of cycles, being outside this range, may be classified as 'abnormal.' The following are the percentages of 'abnormal' cycles for each age-group: 2-tooth, 8.3; 4-tooth, 4.0; 6-tooth, 8.0; full mouth and 5½-year-old, 7.6; and 6½-year-old and over, 8.9. McKenzie and Terrill (1937) found the incidence of 'abnormal' cycles in various breeds to be 9.6 per cent (see also Kelley 1937).

McKenzie and Terrill (1937) believe that cycles shorter than normal may result from an early regression of the *corpus luteum*, and those recurring after an interval of 3 to 6 and 19 to 23 days might be due to the failure of ovulation and subsequent luteinization. Very long cycles

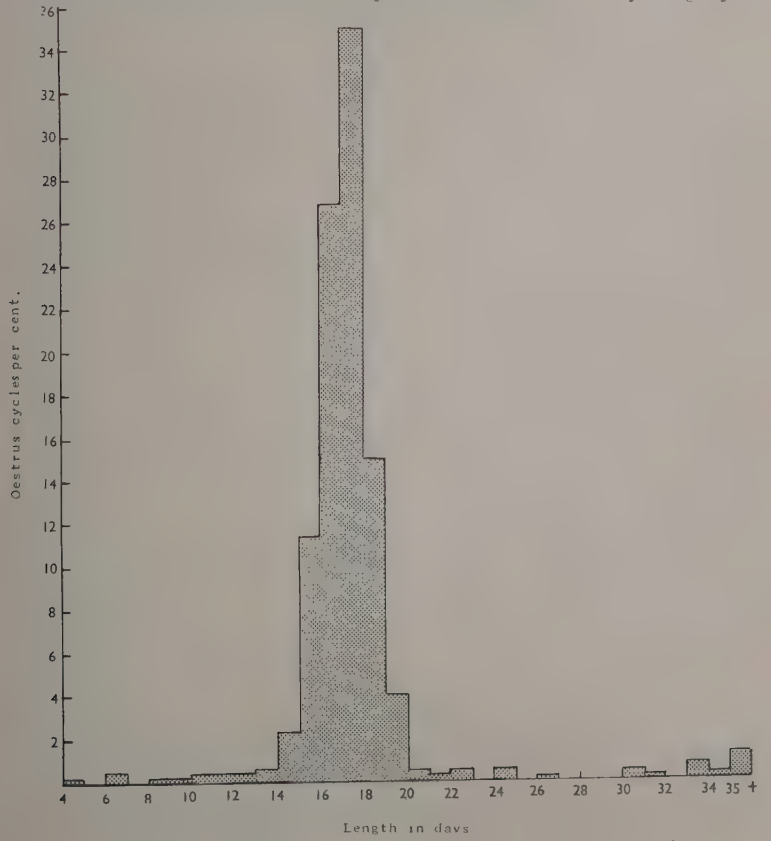


FIG. 2.—Frequency distribution per cent of the length of oestrus cycle.

may be caused by death of the embryo, undetected oestrus or ovulation without oestrus, the latter giving rise to silent heat or weak oestrus, and its length is the sum of two, three or more normal cycles. Silent heat is rather prevalent in Merino (Quinlan *et al.* 1941, and Kelley and Shaw 1943); in the present data, it does not appear to exceed two per cent.

REPEATABILITY OF OCCURRENCE OF THE FIRST OESTRUS

The repeatability of the first oestrus period within the tupping season was measured by correlation technique and the relevant results are given in Table V. Although there were some ewes coming on heat relatively early or late on two or more occasions, the ewes, except in the case of four-tooth versus six-tooth, have not shown any consistency which could be regarded as statistically significant. These results seem to indicate that, at least in the present material, factors other than the heredity make-up of the individual ewes exert the greater influence on the date of the first oestrus within each tupping season. The present findings, however, should be regarded as merely exploratory. The only conclusion that can be put forward with any confidence is that culling ewes for late lambing on the evidence of one or two seasons should be discouraged.

TABLE V. REPEATABILITY OF THE OCCURRENCE OF THE FIRST OESTRUS IN THE TUPPING SEASON IN EWES, AS MEASURED BY COEFFICIENTS OF CORRELATION

			D.F.	r
2-tooth	vs.	4-tooth	149	0.1023
4-tooth	vs.	6-tooth	104	0.2142*
6-tooth	vs.	Full mouth	91	0.1931
2-tooth	vs.	$\frac{\text{4-tooth} + \text{6-tooth}}{2}$	77	0.1501
4-tooth	vs.	$\frac{\text{2-tooth} + \text{6-tooth}}{2}$	77	0.1448

* significant at 5 per cent point.

MATING OF RAMS BY HAND-SERVICE

Although hand-service is probably of considerable importance in breeding stud sheep, there has been little, if any, study of the utilization of rams mated by hand-service under ordinary stud-farm conditions. The material here presented touches some of these matters and is based on the records of five rams which were hand-served in Stud B.

Number of Ewes per Ram

As hand-service is mainly employed as a means for increasing the number of progeny by a given sire, it follows, all other things being equal, that the minimum number of ewes given to a ram for hand-service would be at least equal to the maximum number of ewes put to a ram in ordinary paddock mating. This, as shown in Part II (Goot 1946b), is about 75 ewes per ram. The greatest number of ewes hand-served by one ram was about 180 (Table VI), the average being 144. The above figures are probably indicatory only, for much depends on the season, fertility, vigour, and age of individual rams, as well as on the stud master's breeding policy and skill. It appears, therefore, that in comparison with the paddock mating, the hand-service method can at least double or treble the number of ewes put to a ram.

TABLE VI. UTILIZATION OF RAMS DURING HAND-SERVICE SEASON

Sire		1/38	2/39	3/43	6/32	7/35
Year		1940	1941	1945	1940	1937
No. of Ewes served		179	131	156	101	155
No. of tuppings*		207	158	200	127	279
Average number of tuppings per ewe**		1.1	1.2	1.2	1.3	1.8
Tupping season in days		51	51	55	52	68
Working days		40	42	46	39	57
Idle days	No.	11	9	9	13	11
	%	21.6	17.6	16.4	25.0	16.2
Average number of tuppings per day		4.1	3.1	3.6	2.4	4.1
Average number of tuppings per working day		5.2	3.8	4.3	3.3	4.9
Maximum number of tuppings per day		13	18	12	9	15

* The figures include also repeated services within the oestrus period; hence the slight discrepancy with the figures given in Table VIII.

** The averages were calculated on the basis of one service per oestrus period.

Utilization of Rams

Some further information on the day-to-day activities of hand-served rams is also given in Table VI. The tupping season for the five rams lasted from 51 to 68 days, with an average of 55.4 days. However, services were not performed on every day; the actual 'working' days ranged from 39 to 57, with an average of 44.8 'working' days per season. Similarly, days on which no service was performed, because there were no ewes on heat, ranged from 9 to 13, with an average of 10.6 days per season, or, in other words, the rest period ranged from 16 to 25 per cent, with an average of 19 per cent of idle days per season.

Number of Tuppings per day

An example of day-to-day reproductive activities of a ram is given in Fig. 3. Similar graphs were obtained for all the other rams tabulated in Table VI, and although they are not strictly comparable, owing to differences in the number of ewes served, number of tuppings per ewe, age, season, etc., their most common features are: (1) the irregular character of the curves, indicating that the more intensive periods of tupping were interspaced with less intensive and/or rest periods; (2) the peak periods during which the rams were obliged to work more steadily and perform a maximum of from 9 to 18 services a day.

On the whole, the intensive periods, except during the peak period, were of short duration and well spaced. The average number of tuppings per day for all days ranged from 2.4 to 4.1 for individual rams, and for 'working' days from 3.3 to 5.2 with the mean values of 3.5 and 4.3 services per day and per 'working' day respectively. In view of the

TABLE VII. FREQUENCY OF TUPPINGS PER DAY, I.E., THE NUMBER AND PERCENTAGE OF DAYS DURING WHICH THE RAMS PERFORMED VARYING NUMBER OF SERVICES FROM 0 TO 18

Sire.*	Days.	No. of tuppings per day.																			Total Days.	Days with 0-3 tuppings
		0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18		
1/38	No.	11	4	4	6	6	4	5	1	3	4	1	—	—	2	—	—	—	—	—	51	25
	%	21.6	7.8	7.8	11.8	11.8	7.8	9.8	2.0	5.9	7.8	2.0	—	—	3.9	—	—	—	—	—	100.0	49.0
2/39	No.	9	13	10	6	3	3	1	1	—	—	1	—	1	1	1	—	—	—	1	51	38
	%	17.6	25.5	19.6	11.8	5.9	5.9	2.0	2.0			2.0		2.0	2.0	2.0				2.0	100.3	74.5
3/43	No.	9	13	4	6	4	3	6	3	1	2	—	1	3	—	—	—	—	—	—	55	32
	%	16.4	23.6	7.4	10.9	7.4	5.4	10.9	5.4	1.8	3.6		1.8	5.4							100.0	58.3
6/32	No.	13	16	5	4	4	1	1	4	2	2	—	—	—	—	—	—	—	—	—	52	38
	%	25.0	30.8	9.6	7.7	7.7	1.9	1.9	7.7	3.8	3.8	—	—	—	—	—	—	—	—	—	99.9	73.1
7/35	No.	11	9	15	5	5	2	5	1	2	2	5	3	1	—	1	1	—			68	40
	%	16.2	13.2	22.0	7.4	7.4	2.9	7.4	1.5	2.9	2.9	7.4	4.4	1.5	—	1.5	1.5	—	—	—	100.1	58.8

* Number and year of birth of the sire.

Table VIII. Average Number of Tuppings Per Ewe

Age of Dams.	Tuppings by Sires 4/36* and 5/38*(1939)					Tuppings by Sire 1/38* (1940).					Tuppings by Sire 6/32* (1940).				
	I.	II.	III.	Total.	Aver. per ewe.	I.	II.	III.	Total.	Aver. per ewe.	I.	II.	III.	Total.	Aver. per ewe.
2-tooth	81	19	1	101	1.3	20	4	1	25	1.3	25	10	1	36	1.4
4-tooth	38	8	—	46	1.2	60	5	2	67	1.1	31	4	1	36	1.2
6-tooth	36	11	1	48	1.3	15	3	—	18	1.2	29	5	—	34	1.2
Full Mouth and 5½ years	55	16	2	73	1.3	40	4	—	44	1.1	16	4	—	20	1.3
6½ years and over	20	3	—	23	1.2	44	5	—	49	1.1	—	—	—	—	—
Total	230	57	4	291	1.3	179	21	3	203	1.1	101	23	2	126	1.3

Age of Dams.	Tuppings by Sire 2/39* (1941).					Tuppings by Sire 1/38* (1941).					Tuppings by Sire 2/39* (1942).				
	I.	II.	III.	Total.	Aver. per ewe.	I.	II.	III.	Total.	Aver. per ewe.	I.	II.	III.	Total.	Aver. per ewe.
2-tooth	34	14	3	51	1.5	15	6	—	21	1.4	43	16	1	60	1.4
4-tooth	16	2	—	18	1.1	9	4	—	13	1.4	25	5	—	30	1.2
6-tooth	35	2	—	37	1.1	24	13	2	39	1.6	5	1	—	6	1.2
Full Mouth and 5½ years	22	2	—	24	1.1	16	12	2	30	1.9	23	3	—	26	1.1
6½ years and over	24	3	—	27	1.1	12	6	—	18	1.5	—	—	—	—	—
Total	131	23	3	157	1.2	76	41	4	121	1.6	96	25	1	122	1.3

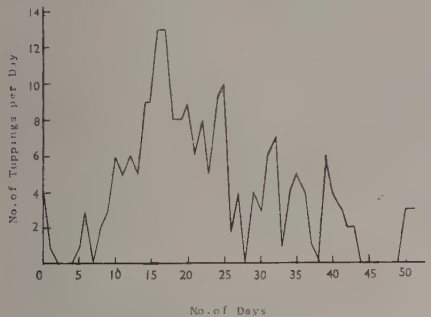
* Number and year of birth of the sire.

TABLE VIII. (Continued)

Age of Dams.	Tuppings by Sire 8/35* (1942).					Tuppings by Sire 3/43* (1945).					Total Tuppings by all Sires.				
	I.	II.	III.	Total.	Aver. per ewe.	I.	II.	III.	Total.	Aver. per ewe.	I.	II.	III.	Total.	Aver. per ewe.
2-tooth	9	2	1	12	1.3	71	11	6	88	1.2	298	82	14	394	1.32
4-tooth	15	5	—	20	1.3	25	6	—	31	1.2	219	39	3	261	1.19
6-tooth	11	3	—	14	1.3	21	3	2	26	1.2	176	41	5	222	1.26
Full Mouth and 5½ years	5	3	—	8	1.6	31	4	—	35	1.1	208	48	4	260	1.25
6½ years and over	—	—	—	—	—	8	—	—	8	1.0	108	17	—	125	1.16
Total	40	13	1	54	1.4	156	24	8	188	1.2	1,009	227	26	1,262	1.25

* Number and year of birth of the sire.

character of the curves the average is of little value. A truer perspective of the activities of a ram may be gained by recalculating the original figures on the basis of the number of days on which the rams performed services varying in number from 0 to 18. These data are summarized in Table VII and an example is given in Fig. 3b. It will be observed that a fair proportion of days is spent either idly or with one, two or three services per day. In fact, between half and three-quarters of all the days are spent in that way. On the other hand there were days during which a ram was used very intensively. As far as the writer is aware, there is little information available on the effect of the fertility of the ram of varying numbers of services daily. It would seem, therefore, highly desirable that further investigations be made in this direction.



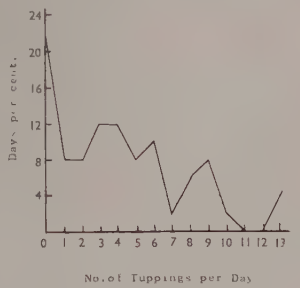


FIG. 3a.—Number of tuppings per day during the 1940 tupping season; ram 1/38 mated by hand-service to 178 ewes. (See Table VI.)

FIG. 3b.—Frequency distribution per cent of tuppings for the same ram in the same season. (See Table VII.)

Number of Tuppings per Ewe

Material available from Stud B on the average number of tuppings per ewe is summarized in Table VIII. Owing to the nature of the data the following reservations should be kept in mind:—

(a) One or more services per heat period were counted as one tupping; (b) it was not always possible to separate all the ewes allotted to each ram, a few 'returning' ewes being mated with other rams; (c) the word 'settle' does not necessarily mean that the ewe conceived. A ewe is considered 'settled' when she has not returned to the ram, or the ram has been withdrawn at the end of the tupping season.

The average number of tuppings per ewe, based on eight records of seven hand-served sires was 1.3.

The average number of tuppings per ewe calculated according to age of ewes ranged from 1.0 to 1.9. The differences between these age-group averages were statistically not significant.

Table VIII tabulates also the number of ewes served once, twice, and three times during the breeding season. Of the total of 1,009 ewes, 227 or 22.5 per cent were served twice and 26 or 2.6 per cent three times. Out of the 227 returning for the second time, 26, or 11.5 per cent, returned for the third time. In other words, 782 ewes, or 77.5 per cent, were settled after the first service and 201 or 88.5 per cent after the second.

Quinlan and Maré (1931) calculated the following percentages of South African Merinos fertilized in successive hand-services: first service, 50.2; second, 37.4; third, 48.9; fourth, 23.5; and fifth, 16.7. Roux and

Rensburg (1935) found abnormally large percentages of South African Merino ewes not 'settled' at the first service; viz., 32.1 per cent with two Border-Leicester rams; 37.9 per cent with two Ryeland rams; 70.6 per cent with two Southdown rams; and 12 per cent with one Merino ram. Kardymovich (1932) stated that 74 per cent of the Voloshian ewes were fertilized after the first mating.

The above figures (with the possible exception of the latter) refer to hand-service. Kelley (1937) found that 'paddock-mating' was significantly better than 'hand-service.'

No similar data, as far as the writer is aware, have been published in this country for Romney Marsh sheep, and therefore it is not possible to say how representative are the figures here presented. Further studies on the tupping season and factors affecting it, would seem desirable.

The lambing season will be discussed in a subsequent paper.

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